Corrosion of Roof Truss Gusset Plates in Farm Buildings

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Factsheet

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CORROSION PROBLEM

Deterioration of metal truss gusset plates is a major concern in buildings that contain high humidity and corrosive environments. Many of these buildings show severe corrosion within 5–10 years. Normal galvanized steel plates exposed to moisture, condensation and ventilation air containing manure gases will corrode rapidly. This corrosion can weaken the building and could potentially lead to structural failure.

Truss plates are light-gauge metal plates used to connect prefabricated wood trusses. They are produced by punching light-gauge galvanized steel (normally 16-, 18- or 20-gauge) so teeth protrude from one side, as shown in Figure 1. The truss plates can be galvanized prior to punching, leaving numerous unprotected metal edges. During truss fabrication, these truss plates are pressed into the lumber with either a hydraulic press or a roller to fully embed the teeth.

The buildings most affected by this corrosion are cold, naturally ventilated beef and dairy barns with slatted floors and deep manure storages. Also affected are warm, naturally ventilated swine barns. These buildings often expose the entire truss assembly to a potentially wet service condition. In most cases, farm trusses are designed for a dry service condition.

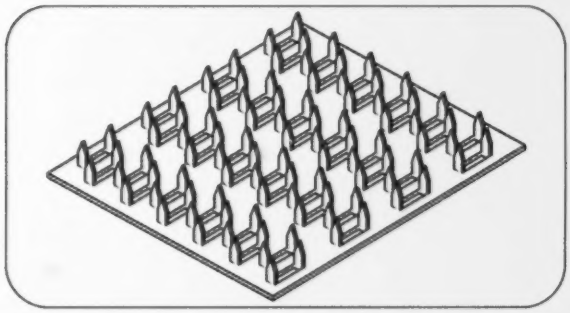

Figure 1. Drawing of a typical truss plate.

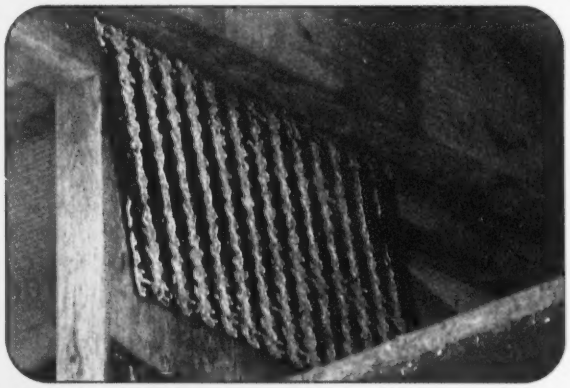

Figure 2. This gusset plate is beginning to show signs of rust and deterioration.

Figure 2 shows the degradation that can occur when the roof trusses are included in the environmental air space of a building — the gusset plate is beginning to rust. In contrast, Figure 3 shows a gusset plate that has been in place for a longer period of time, but only used in an equipment storage building. This joint is still in good condition because it has not been exposed to corrosive environmental conditions.

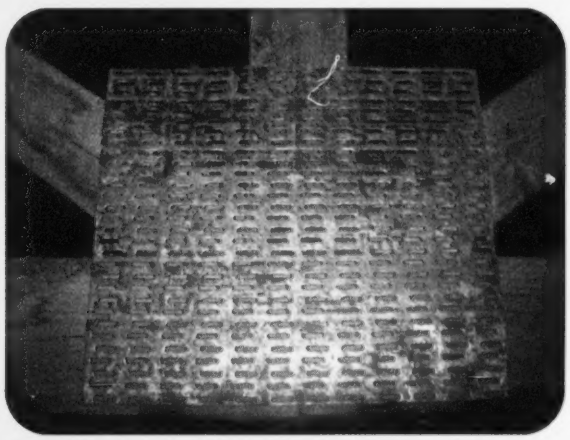

Figure 3. An older gusset plate still in good repair.

Ministry of Agriculture, Food and Rural Affairs

Ontario

Truss plates often show the greatest deterioration near the building air exchange openings, typically at the heel and peak joints of the truss — the areas of greatest air mixing and temperature change, producing high humidity and condensation problems. Unfortunately, these are also very critical joints in the structural integrity of the truss.

When installing rooftop solar modules, be sure to check these connectors during the full facility review. Even if the building has been securely in place for a number of years, do not assume that corroding gusset plates can handle additional loads.

CAUSES OF CORROSION

There are many potential causes of corrosion in animal buildings. Animals exhale large quantities of moisture into the air, creating high relative humidity in the building if the moisture is not properly vented. High humidity increases the potential for condensation, which wets the entire truss assembly.

Ammonia gas, typically found in animal environments, combines readily with this moisture and becomes ammonium hydroxide, a chemical that attacks most metal surfaces. Free moisture on poorly protected steel will also initiate the rusting process. The moist wood accelerates the corrosion of the metal fasteners since wood itself is slightly acidic. In addition, long-term wetness can raise wood moisture content above 30% and accelerate wood decay.

Dust, commonly found in animal environments, provides a surface on which acids and gases can react, significantly accelerating the rate of corrosion. Common bacterial colonies found in barns tend to form biofilms on building and equipment surfaces, allowing bacterial growth and the production of other corrosive acids.

PREVENTION OF CORROSION

Properly Ventilate the Building

A good ventilation system should move enough fresh air through the building to reduce the levels of moisture, gas and dust to acceptable levels. A well-designed system will minimize corrosion problems. Proper ventilation requires good building design and good ventilation management. A ventilation specialist, equipment supplier or building contractor can help ensure that ventilation issues are not contributing to the corrosion problem.

Often, an owner tightens up a barn to raise the building temperature or to save on supplemental heat. Unfortunately, this reduces the ventilation rate and allows the humidity level to increase. In fan-ventilated barns, keep at least one exhaust fan operating to constantly remove the respired moisture. Similarly, naturally ventilated barns require a constant exchange of air to control moisture. Additionally, barns with continuous ridge ventilation provide a condensing surface at every peak truss connection along the barn. Situating chimneys intermittently between the trusses keeps this ventilation air away from the truss plates and reduces the potential for corrosion.

Apply a Protective Coating to Metal Truss Plates

Apply a protective coating to the plates by brush either before or after truss installation. Surface preparation is important. Roughen and clean the substrate and cover each metal plate, including its edges, with the coating. One of the recommended epoxy coatings that is lead- and chromate-free is Epoxy-Polyamide Primer and Topcoat (SSPC Paint No. 22 or CGSB Paint No. 1-GP-146). SSPC refers to the Steel Structures Painting Council (U.S.), and CGSB refers to the Canadian Government Specifications Board.

This epoxy paint is a two-component product that requires specific mixing and application expertise. Prepare the plates with a cleaning solvent or by sandblasting prior to coating or as per the requirements of the SSPC SP16 procedure. This task could be undertaken by a commercial painter, building contractor or the owner. It is a labour-intensive job that will be only as effective as the quality of workmanship employed. A truss manufacturer or industrial paint supplier can help find this coating material or an equivalent product. In some cases, the extra step of boxing each coated connector with plywood has been taken. Ultimately, the person responsible for your roof design will have to specify what needs to be done.

Use Pre-coated or Stainless Steel Truss Plates

Various pre-coated and stainless steel truss plates are available, however, they are expensive. Coated truss plates are almost five times the price of standard G90 galvanized plates. They must be larger than standard plates because of their slippery surface. Also, because they are coated before truss assembly, they may get chipped before they are installed in your building, creating opportunities for corrosion.

Stainless steel plates are also quite expensive, which can make a significant difference in the total cost of the truss. Not all suppliers stock these plates, so factor in delivery time. In all cases, it is important that the truss designer and manufacturer understand your service conditions. When this is known in advance, the proper materials can be selected for your project.

Install Ceiling with Insulation and a Vapour Barrier

If the truss assembly is completely partitioned out of the animal environment, it will not be influenced by the high humidity condition and related problems. A 4- or 6-mil polyethylene vapour barrier where the seams are taped is necessary to prevent moisture migration into the attic space. Steel or plywood ceilings by themselves do not provide an adequate vapour barrier. The sheet seams, fasteners and material porosity will allow moisture to pass through. A minimum amount of ceiling insulation is also required to prevent condensation from occurring on the ceiling surface itself.

To mitigate the impact of barn air entering the area, ventilate the attic area to allow moisture to escape by allowing fresh air to enter along both the eave and soffit areas. It is still possible to allow the air to escape by installing exhaust chimneys through the attic space between the trusses, as shown in Figure 4. For more information, see OMAFRA Publication 833, *Ventilation for Livestock and Poultry Facilities*, Chapter 8, Attic Ventilation, and consult a ventilation designer for the correct size and number of chimneys required.

Figure 4. A naturally ventilated barn with chimneys through the attic space.

REPAIR RECOMMENDATIONS

- If the truss deterioration is minor, employ one or more of the prevention procedures outlined above to halt further corrosion.
- If the deterioration is more severe, consider a structural repair. Have a consulting engineer conduct an assessment and repair specification. The Ontario Building Code requires roof systems to be engineered.

SUMMARY

While the extent of the truss deterioration problem is not known, it is a very serious situation for those buildings affected. Owners should inspect their buildings periodically for signs of wetness and corrosion on the truss plates. Initiate a repair if necessary. A building contractor, truss manufacturer or engineering consultant can assist you. The building repair or retrofit expenditure undertaken now will most likely be cheaper than replacing the structure prematurely.

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